SPECIFICATION

INTERNAL COMBUSTION ENGINE HAVING FUEL INJECTION VALVE WITH MECHANISM FOR REGULATING NEEDLE VALVE SPRING FORCE, AND METHOD OF REGULATING FUEL INJECTION VALVE

Technical field

The present is applied to internal combustion engines having fuel injection valves such as diesel engines and gas engines, and relates to an internal combustion engine having a fuel injection valve which is composed such that a needle valve is pushed up against the loading force of needle valve springs by the pressure of fuel fed under high pressure from a fuel injection pump, thereby the needle valve is opened and the fuel is injected into a combustion chamber from injection holes formed in the head of a nozzle chip and which is provided with a mechanism for adjusting preloading force of the needle valve springs, and a method of the adjusting preloading force of the needle valve springs.

Background art

There has been proposed a variety of arts in which the fuel injection valve of a diesel engine is composed such that the needle valve is pushed up against the loading force of needle valve springs by the pressure of the fuel fed under high pressure form the injection pump to open the needle valve to injecte the fuel into the combustion chamber from the nozzle holes formed in the head of the

nozzle chip, whereby the opening of the needle valve is effected in two-stage, first stage opening at low pressure and second stage opening thereby to further increase opening area at higher pressure, and by this two-stage injection with low and high pressure, improvement in combustion and exhaust emission is attained.

One of arts like this is disclosed in Japanese Laid-Open Patent Application No.2-81948. In this art, two springs are provided for loading one needle valve along the axis of the needle valve, one is a low pressure spring and the other is a high pressure spring, and the preloading force of each of the springs is set to be different from each other. The low pressure spring supported against the lower end face of a fixed member through the intermediary of a shim at its upper end face is applied at its lower end face against the upper end of the needle valve by way of a push rod which serves as a first movable spring seat to push the needle valve in the opening direction, and the high pressure spring is supported at its upper end face against the lower end face of a push rod supporting member through the intermediary of a shim and applied at its lower end face against a second movable spring seat lying on a distance piece disposed on the top face of a nozzle body, whereby the needle valve is moved up in the opening direction when fuel pressure exceeds the preloading force of the low pressure spring to inject the fuel at a lower pressure, and the needle valve is further moved up in the opening direction when the sum of the loading force of the low

pressure spring and the preloading force of the high pressure spring is surmounted by fuel pressure to inject the fuel at a higher pressure with increased valve opening.

In the prior art, a shim(first stage opening pressure adjusting shim) is inserted between a stationary stop face and the upper end face of the low pressure spring, and a separate shim (second stage opening pressure adjusting shim) is inserted between the bottom end face of a push rod supporting member provided slidably above the high pressure spring and the upper end face of the high pressure spring. When adjusting the preloading force of the low pressure spring or high pressure spring, the shim on the upper end face of the low pressure spring or the shim on the upper end face of the high pressure spring is replaced by a shim of differing thickness, whereby it is necessary to disassemble the fuel injection valve for the displacement.

Therefore, when adjusting the valve opening pressure or the pressure for further lifting up the needle valve(hereafter the former is referred to as lower valve opening pressure and the latter as higher valve opening pressure), it is necessary to disassemble the fuel injection valve to replace the first stage opening pressure adjusting shim or second stage opening pressure adjusting shim, which is vexatious and requires significant man-hours.

Particularly, when it is required to adjust the valve opening pressure of a fuel injection valve for a specific cylinder during operation of the engine, the relevant

fuel injection valve must be detached from the cylinder head and disassembled to replace the shim or shims to change the thickness thereof, and operability and maintainability of the engine is greatly deteriorated.

Disclosure of the Invention

The present invention was made in light of the problems mentioend above, and its object is to provide an internal combustion engine equipped with a fuel injection valve which is provided with a mechanism for adjusting preloading force of each of two needle valve springs thereby enabling improvement in operability and maintainability of the engine, in which two stages of valve opening pressure is easily adjustable with high accuracy in the state the fuel injection valve is installed to the cylinder head of the engine and without disassembling the fuel injection valve, with the result that time required to adjust valve opening pressure can be drastically reduced, and also to provide a method of adjusting valve opening pressure of the injection valve.

To attain the object, the present invention proposes an internal combustion engine equipped with a fuel injection valve provided with a mechanism for adjusting preloading force of valve springs, a needle valve being lifted up against valve spring force by fuel pressure supplied under high pressure from an injection pump to open the injection valve and allow the fuel to be injected into a combustion chamber of the engine through injection openings provided at a nozzle chip end, wherein said fuel

injection valve is provided with two needle valve springs and two adjusting screw members each for adjusting the preloading force of each of the adjusting screw members independently.

In the invention, it is preferable that said two valve springs consisting of a first stage spring and a second stage spring are set to be different in preloading force by means of said two adjusting screw members, a first stage adjusting screw member and a second stage adjusting screw member, respectively, said first stage and second stage springs being disposed tandem along the center axis of the needle valve, said first stage and second stage adjusting screw members being disposed tandem along the center axis of the needle valve.

Further, to be concrete, it is preferable that said first adjusting screw member for adjusting the preloading force of said first stage spring is connected to an upper support of said first stage spring so that said needle valve is always loaded in its closing direction by said first stage spring, said second stage spring is accommodated in an upwardly open hollow of said first stage adjusting screw member, and said second stage adjusting screw member for adjusting the preloading force of said second stage spring is disposed above said first stage adjusting screw member and connected to said second stage spring so that said needle valve is loaded in its closing direction by said second stage spring after said needle valve is lifted up by a specific lift against the loading force of said first stage spring.

As a method of adjusting the fuel injection valve of an internal combustion engine is proposed, which is characterized in that first stage(lower pressure) valve opening pressure is adjusted by changing by means of a first stage adjusting screw member preloading force of a first stage spring incorporated in a valve main body to load a needle valve in its closing direction, and second stage(higher pressure) valve opening pressure is adjusted by changing by means of a second stage adjusting screw member preloading force of a second stage spring incorporated in said valve main body to load said needle valve in its closing direction after said needle valve is lifted up by a specific lift against the loading force of said first stage spring.

According to the invention, opening pressure of the needle valve can be adjusted by changing the preloading force of each of the first and second stage springs provided tandem along the center axis of the one needle valve, with the preloading force of each of the springs being set differently. First stage valve opening pressure, that is, lower valve opening pressure, is adjusted by changing the penetration depth of the first stage adjusting screw member to change the preloading force of the first stage spring. Second valve opening pressure, that is, higher valve opening pressure(to put it precisely, this is a pressure at which the needle valve begins to lift up further from the position the needle valve has been lifted up by the first stage valve opening), is adjusted by changing the penetration depth of the second stage

adjusting screw member to change the preloading force of the second stage spring. The sum of the loading force of the first stage spring when the needle valve is lifted up by a specific lift, i.e. a first stage valve lift and the preloading force of the second stage spring determines the second stage(higher pressure) valve opening pressure.

Therefore, according to the invention, first stage valve opening pressure can be adjusted steplessly by changing the penetration depth of the first stage adjusting screw member and second stage valve opening pressure can be adjusted steplessly by changing the penetration depth of the second stage adjusting screw member.

Therefore, according to the invention, when adjusting valve opening pressure of the injection valve, the first stage(lower pressure) valve opening pressure and the second stage (higher pressure) valve opening pressure can be adjusted respectively independently, easily, and steplessly by changing the penetration depth of the first stage adjusting screw member or that of the second stage adjusting screw member, so that it is not necessary to disassemble the fuel injection valve and replace a shim or shims by those of differing thickness every time when adjusting the first stage or second stage valve opening pressure as is in the case of the prior art disclosed in the patent literature 1, and time required to adjust valve opening pressure can be drastically reduced.

Further, according to the embodiment, even if the

condition occurs to require adjustment of the fuel injection valve for a specific cylinder during operation of an engine, the fuel injection valve can be adjusted in valve opening pressure in the state it is installed to the cylinder head. The first stage(lower pressure) valve opening pressure or second stage(higher pressure) valve opening pressure can be adjusted only by changing the penetration depth of the first stage adjusting screw member or second stage adjusting screw member respectively, so that the operability and maintainability of the engine can be drastically improved in comparison with the prior art.

In the invention, it is preferable an annular gap is provided between either a periphery of an upper or lower spring support of said first stage spring and a counter bore for receiving the periphery, and an annular gap is provided between either a periphery of said upper spring support or a lower spring support of said second stage spring and a counter bore for receiving the periphery, thereby accommodating slanting of said first stage and second stage springs respectively.

With this construction, even if the first stage spring or second stage spring disposed in tandem with one another is slanted owing to insufficient accuracy of the springs or appurtenant components, the slanting can be accommodated by the annular gap provided between either a periphery of an upper or lower spring support of said first stage spring and a counter bore for receiving the periphery and the annular gap provided between either

a periphery of said upper spring support or a lower spring support of said second stage spring and a counter bore for receiving the periphery.

Further, in the invention, it is preferable that the lower end of the lower spring support of said first stage spring is applied against the top end of said needle valve; the upper end of a push rod, with its lower end contacting closely to the upper end of the lower spring support of the first stage spring, can come into contact with the lower end of the lower spring support of said second stage spring when said needle valve is lifted up by a specific lift, the upper end of the upper spring support of said first stage spring is applied against the lower end of said first stage adjusting screw member, the upper end of the upper spring support of said second stage spring is applied against the lower end of said second stage adjusting screw member, and further each of the contacting face of the push rod with the lower spring support of the first stage spring and the contacting face of the upper spring support of the second stage spring with the second stage adjusting screw member takes a form of spherical contact face respectively.

With this construction, by allowing the relatively long push rod to come into spherical contact with the first stage spring lower support, the push rod can be prevented from sticking due to slanting of the push rod and occurrence of faults in needle valve motion can be avoided. Further, by allowing the upper support of the second stage spring to come into spherical contact with the second stage

adjusting screw member, sticking of the second stage adjusting screw member due to out of alignment between the second stage adjusting screw member and the second stage spring upper support and second stage spring can be avoided.

In the invention, it is preferable that the lower end of the lower spring support of said first stage spring is applied against the top end of said needle valve, and the upper end of said push rod comes into contact with the lower end of the lower spring support of said second stage spring in plane surface contact when said needle valve is lifted up by a specific lift.

Further, the second stage spring and its appurtenant members are removed from the fuel injection valve which is constructed such that; said two valve springs consisting of a first stage spring and a second stage spring are set to be different in preloading force by said two adjusting screw members, a first stage adjusting screw member and a second stage adjusting screw member, respectively, said first stage and second stage springs being disposed tandem along the center axis of the needle valve, said first stage and second stage adjusting screw members being disposed tandem along the needle valve; and said first adjusting screw member for adjusting the preloading force of said first stage spring is connected to an upper support of said first stage spring so that said needle valve is always loaded in its closing direction by said first stage spring, said second stage spring is accommodated in an upwardly open hollow of said first

stage adjusting screw member, and said second stage adjusting screw member for adjusting the preloading force of said second stage spring is disposed above said first stage adjusting screw member and connected to said second stage spring so that said needle valve is loaded in its closing direction by said second stage spring after said needle valve is lifted up by a specific lift against the loading force of said first stage spring; when carrying out adjustment of first valve opening pressure to ease the adjustment, which is carried out by adjusting the preloading force of said first stage spring by means of said first stage adjusting screw member.

According to the invention, first stage valve opening pressure can be carried out with ease in the state the second stage spring and its appurtenant members are removed, and second stage valve opening pressure can be carried out by incorporating the first stage spring and its appurtenant members together with the second stage spring and its appurtenant members.

Thus, first stage(lower pressure) valve opening pressure and second stage(higher pressure) valve opening pressure of the fuel injection valve can be adjusted with ease and accuracy.

Brief Description of the Drawings

FIG.1 is a sectional view of the first embodiment of the present invention.

FIG.2 is a sectional view as in FIG.1.of the second embodiment.

FIG.3 is a sectional view as in FIG.1.of the third embodiment.

FIG.4 is a sectional view as in FIG.1.of the fourth embodiment.

Best mode for embodiment of the Invention

A preferred embodiment of the present invention will now be detailed with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, relative positions and so forth of the constituent parts in the embodiments shall be interpreted as illustrative only not as limitative of the scope of the present invention.

FIG.1 is a sectional view of the first embodiment of the present invention. FIG.2 is a sectional view as in FIG.1.of the second embodiment, FIG.3 is a sectional view as in FIG.1.of the third embodiment, and FIG.4 is a sectional view as in FIG.1.of the fourth embodiment.

Referring to FIG.1 showing the first embodiment of the invention, reference numeral 1 is a valve main body, a main body cover 2 is screwed-in on the outer periphery of the upper part of the valve main body 1, a second stage adjusting screw member 18 for adjusting the preloading force of a second stage spring 14 is screwed into the upper part of the main body cover 2, and a lock nut 19 is screwed on the outer periphery of the upper part of the second stage adjusting screw member 18 to lock it against independent rotation. A gasket 18a is provided between the main body cover 2 and lock nut 19 for

fluid-tight sealing. A screw plug 20 is screwed in a screw hole in the upper part of the lock nut 19.

Reference numeral 3 is a nozzle chip firmly clamped by way of a spacer 25a, which is provided between the top face of the nozzle chip 3 and bottom face of the valve main body 1, by means of a nozzle nut 5 axially against the valve main body 1, the nozzle chip 3 having a plurality of injection openings 4 at its head part. Reference numeral 8 is a fuel path through which high-pressure fuel is introduced from a fuel injection pump. Reference numeral 7 is a fuel pool in the nozzle chip 3 into which the fuel path 8 opens and which is connected by an annular gap between the periphery of a needle valve 6 and the inner periphery of the nozzle chip below the fuel pool 7 to the valve seat in the nozzle chip 3. Reference numeral 1a is a fuel leak bore. The needle valve 6 is fitted in the nozzle chip 3 for reciprocation. Reference numeral 24 is a gasket provided between the nozzle nut 5 and a cylinder head not shown in the drawing.

Reference numeral 9 is a first stage spring which serves as a low pressure spring and pushes the needle valve 6 by the intermediary of a first stage spring lower support 10 of which the lower end contact to the top end of the needle valve 6.

Reference numeral 22 is a first stage spring upper support of hollow cylinder shape supporting the upper end face of the first stage spring 9. The first stage spring upper support 22 is formed into a hollow cylindrical shape and fitted slidably in the valve main body 1, and

its upper end face is applied against the lower end face of a first stage adjusting screw member 16 which is explained later by the preloading force of the first stage spring 9. Reference numeral 21 is a lock nut to lock the first stage adjusting screw member 16 against independent rotation.

Reference numeral 25 is a locating pin to determine the rotation position of the nozzle chip 3 relative to the spacer 25a, and 11 is a locating pin to determine the rotation position of the spacer 25a relative to the valve main body 1.

Reference numeral 14 is a second stage spring which serves as a high pressure spring. Said first stage adjusting screw member16 has a threaded part on the outer periphery thereof and a hollow space inside it where the second stage spring 14 is accommodated and is screwed into the upper opening of the valve main body 1. Reference numeral 23 is a second stage spring upper support supporting the upper end face of the second stage spring 14, and 13 is a second stage spring lower support supporting the lower end face end face of the second stage spring 14. The upper end face of the second stage spring upper support 23 is applied against the lower end face of the second stage adjusting screw member 18, and the lower end face of the second stage spring lower support 13 is applied against the bottom face of the hollow of the first stage adjusting screw member 16 by the preloading force of the second stage spring 14. In Fig.1 is shown the state a push rod 12, which is fitted slidably in the first stage

spring upper support 22, has pushed up the second stage spring lower support 13 by the lifting of the needle valve 6 against the restoring force of the first stage and second stage springs 9 and 14 and second stage fuel injection is effected. The lower end face of the push rod 12 is applied against the upper end face of the first stage spring lower support 10 by the preloading force of the first stage spring 9, and its upper end face comes into contact with the lower end face of the second stage spring lower support 13 when the needle valve 6 is lifted by a specific lift, i.e. the first stage lift. The upper end face of the push rod 12 and the lower end face of the second stage spring lower support 13 are flat so that the push rod 12 comes into plane contact indicated by reference numeral 12a with the second stage spring lower support 13.

Although the push rod 12 is formed into a bar shape and fitted in the bore of the first stage spring upper support 22 in thr embodiment, it is possible to make the push rod 12 in one piece with the first stage spring lower support 10. In this case, the number of the parts is reduced and labor hour of assembling can be saved.

In operation of an engine provided with the fuel injection valve like this, high-pressure fuel supplied from a fuel pump not shown in the drawing under high pressure through a high-pressure fuel pipe not shown in the drawing passes through the fuel path 8 to reach the fuel pool 7. When the pressure of the high-pressure fuel exceeds such a specific pressure as lift up the needle

valve 6 against the restoring force of the first stage spring 9, the needle valve 6 is lifted up until the upper end face of the push rod 12 comes in conatct with the lower end face of the second lower spring support, thereby opening the injection valve to allow the high-pressure fuel to be injected through the injection openings 4. This is first stage injection of low pressure.

Then, when the fuel pressure further increases and exceeds a specific pressure as further lift up the needle valve 6 against the restoring force of the first stage spring 9 and second stage spring 14, the needle valve 6 is further lifted up until the shoulder face thereof comes into contact with the lower end face of the spacer 25a, and second stage injection of high pressure is effected through the injection openings 4.

When adjusting valve opening pressure, first the main body cover 2 is removed and the preloading force of the of the first stage spring 9 is adjusted by rotating the first stage adjusting screw member 16 to change the penetration depth of the member16 and lock it by the lock nut 21 at the position with which the needle valve opens at a desired first stage opening pressure(lower opening pressure).

Then, the main body cover 2 is screwed in again to the main body cover 2 and the preloading force of the of second stage spring 14 is adjusted by rotating the second stage adjusting screw member 18 to change the penetration depth of the member18 and lock it by the lock nut 19 at a position with which the needle valve opens at a desired second

stage opening pressure(higher opening pressure, to be more precise a pressure at which the needle valve begins to be further lifted up to increase the opening area).

In this way, the lower opening pressure determined by the preloading force of the first stage spring 9 and the higher opening pressure determined by the sum of the preloading force of the first stage spring 9 and second stage spring 14 are set as desired.

According to the embodiment, two stages of needle valve opening pressure can be adjusted by adjusting the preloading force of the first stage spring 9 and preloading force of the second stage spring 14 arranged along the axis of one needle valve 6 at positions separate to each other, the first valve opening pressure, i.e. lower valve opening pressure being set by changing the penetration depth of the first stage adjusting screw member 16 for adjusting the preloading force of the first stage spring 9, and the second valve opening pressure, i.e. higher valve opening pressure(for further lifting up of the needle valve) being set by changing the penetration depth of the second stage adjusting screw member 18 for adjusting the preloading force of the second stage spring 14.

Therefore, according to the embodiment, stepless adjustment
of the first stage(lower pressure) valve opening pressure and second stage(higher pressure) valve opening pressure are possible by adjusting the penetrating depth of the first stage adjusting screw member 16 and second stage

adjusting screw member 18 respectively.

That is, when adjusting valve opening pressure of the injection valve, the first stage valve opening pressure and the second stage valve opening pressure can be adjusted respectively independently, easily, and steplessly by changing the penetration depth of the first stage adjusting screw member 16 or that of the second stage adjusting screw member 18.

Therefore, it is not necessary to disassemble the fuel injection valve and replace a shim or shims with those of differing thickness every time when adjusting the first stage or second stage valve opening pressure as is in the case of the prior art, and time required to adjust valve opening pressure can be drastically reduced.

Further, according to the embodiment, even if the condition occurs to require adjustment of the fuel injection valve for a specific cylinder during operation of an engine, the fuel injection valve can be adjusted in valve opening pressure in the state it is installed to the cylinder head. The first stage valve opening pressure and second stage valve opening pressure can be adjusted by changing the penetration depth of the first stage adjusting screw member 16 and second stage adjusting screw member 18 respectively, so that the operability and maintainability of the engine can be drastically improved.

In the second embodiment shown in FIG.2, an annular gap 31 of radial gap of S_2 is provided between the periphery of the first stage spring lower support 10 and the periphery

of the upper side opening of the spacer 25a for receiving the lower support 10, and an annular gap 30 of radial gap of S_1 is provided between the periphery of the second stage spring upper support 23 and the periphery of the hollow of the first adjusting screw member 16.

According to the second embodiment, even if the first stage spring 9 or second stage spring 14 is slanted due to poor accuracy of constituent members, the slanting is accommodated by the annular gap 31 between the periphery of the first stage spring lower support and the periphery of the upper side opening of the spacer 25a and by the annular gap 30 between the periphery of the second stage spring upper support 23 and the periphery of the hollow of the first adjusting screw member 16, and occurrence of faults in operation of the needle valve 6, spring 9, and spring 14 due to the slanting can be avoided.

Otherwise is identical in construction to the first embodiment, and constituent members similar to those of the first embodiment are denoted by the same reference numerals.

In the third embodiment shown in FIG.3, the upper end face 35 of the second stage spring upper support 23 and the lower end face 36 of the second stage adjusting screw member 18 are spherically shaped respectively to allow spherical contact with each other, and the lower end face 38 of the push rod 12 and the upper end face 37 of the first stage spring lower support 10 are spherically shaped respectively to allow spherical contact with respect to one onother.

According to the embodiment, by allowing the relatively long push rod 12 to come into spherical contact with the first stage spring lower support 10, the push rod 12 can be prevented from sticking due to slanting of the push rod 12 and occurrence of faults in needle valve motion can be avoided. Further, by allowing the second stage spring upper support 23 to come into spherical contact with the second stage adjusting screw member 18, sticking of the second stage adjusting screw member 18 due to out of alignment between the second stage adjusting screw member 18 and the second stage spring upper support 23 and second stage spring 14 can be avoided.

Otherwise is identical in construction to the first embodiment, and constituent members similar to those of the first embodiment are denoted by the same reference numerals.

In the fourth embodiment shown in FIG.4, the second stage spring 14, second stage spring upper support 23, and second stage spring lower support13 are removed(it is permissible to remove also the second stage adjusting screw member 18) from the first embodiment shown in FIG.1, and in this state first stage(lower pressure) valve opening pressure is set by the first stage spring 9 and first stage adjusting screw member 16.

According to the fourth embodiment, adjustment of first stage opening pressure can be carried out with ease and accuracy by the first stage spring 9 and first stage adjusting screw member 16 in the state of the fourth embodiment in which the second stage spring 14 and

appurtenant members are removed from the first embodiment, and adjustment of both of first stage valve opening pressure and second stage valve opening pressure can be carried out in the state the first and second stage springs 9, 14, and the first and second adjusting screw members 16, 18 are incorporated in the fuel injection valve as are in the first embodiment.

Herewith adjustment of first stage(low pressure) valve opening pressure and second stage(high pressure) valve opening pressure can be carried out respectively accurately.

Otherwise is identical in construction to the first embodiment, and constituent members similar to those of the first embodiment are denoted by the same reference numerals.

According to the present invention, when adjusting valve opening pressure of the injection valve, the first stage(lower pressure) and the second stage(higher pressure) valve opening pressure can be adjusted respectively independently, easily, and steplessly by changing the penetration depth of the first stage adjusting screw member or that of the second stage adjusting screw member, and it is not necessary to disassemble the fuel injection valve and replace a shim or shims with those of differing thickness every time when adjusting the first stage or second stage valve opening pressure as is in the case of the prior art, and time required to adjust valve opening pressure can be drastically reduced.

Further, according to the invention, adjustment of valve opening pressure of injection valves can be possible with the injection valves installed to the cylinder head during operation of an engine, and the adjustment of first stage and second stage valve opening pressure can be carried out only by changing the penetration depth of the first stage adjusting screw member for adjusting the preloading force of the first stage spring or second adjusting screw member for adjusting the preloading force of the second stage spring, so that the operability and maintainability of the engine can be drastically improved.

Industrial applicability

The invention provides an internal combustion engine equipped with a fuel injection valve which is provided with a mechanism for adjusting preloading force of each of two needle valve springs thereby enabling improvement in operability and maintainability of the engine, in which two stages of valve opening pressure is easily adjustable with high accuracy in the state the fuel injection valve is installed to the cylinder head of the engine and without disassembling the fuel injection valve, with the result that time required to adjust valve opening pressure can be drastically reduced.